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on light, buds and bursts

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Nature is bursting into life these days. Every year at this time in the Northern hemisphere, and despite what may be troubling the world – wars, forced migrations, terrorism, earthquakes, locusts or, lately, a virus – spring simply unfolds as it always has. Much in the way your grandfather would perhaps stroll down a path, whistling a tune to himself with his hands deep in his pockets and his thoughts miles away, spring, too, seems quite content and happily unconcerned by what is going on around it. Nature can only spring into action, however, if it gets the right cues. And there are several: sunlight and starch to name but two. Thanks to daylight, for instance, plants are able to make carbohydrates – i.e. energy – and then use them for their growth and development. Consequently, sugars are continuously trafficked from one part of a plant to another, and stored or indeed broken down for energy. For shoots to appear along the length of a rose's stem, for example, besides light, sugars are required in huge quantities and, for this, many enzymes are triggered into action. In the common modern rose, *Rosa hybrida*, one such enzyme is a vacuolar invertase – acid beta-fructofuranosidase 1 – which specifically breaks down sucrose to provide rosebuds with what they need to bloom.

Roses #2 (1982), by Art Hansen

Courtesy of the Estate of Art Hanse
Art Hansen at Davidson Galleries, USA

Roses have been grown, crossbred, put on show and their juices extracted for thousands of years. Like so many exotic products, they originated in the East and gradually made their way westwards. In the very early days, roses would not have looked like those we currently admire in public parks or flower shops, but more like the roses we find in the wild: growing on bushes, smaller in size, pinkish in colour and usually quite fragrant. Over the centuries, myriads of crosses between species produced myriads of cultivars defined by their colours, stem strength and flower size for instance – although frequently to the detriment of other traits, notably their scent. In the 18th century, Josephine Bonaparte had a mere 250 different species of roses imported from all over the world which she grew in the gardens of her château outside Paris – 117 of which were drawn by the naturalist Pierre-Joseph Redouté. The roses we know today belong to the so-called modern rose, and are the result of an initial cross made in the 19th century between two older (already fairly crossbred) roses – one from the East, and the other from the West.

Besides their looks, roses have also long been part of various aspects of society and culture. The Greeks attributed their red colour to Aphrodite, the goddess of love, who is said to have wounded herself on a thorn and stained the flower with her blood – the rose then became a symbol for love and immortality. When Christianity spread, bereft of its thorns the rose became, surprisingly, the symbol for the Virgin Mary, and is the origin of the word "rosary". Across the centuries and artistic influences, roses have been drawn and painted to catch the beauty and intricacy of their architecture. Their fragrance has also been extracted for thousands of years to scent perfumes, water, teas, sweets and desserts for instance, especially in the East. Who has not tasted a rose-scented lokum? Who, too, has not been given rose hip as a source of vitamin C?

None of this would exist were it not for daylight. Plants need photons to trigger off all sorts of metabolic pathways that will provide them with the energy they need to flourish. The metabolism plants use to extract energy from photons is called photosynthesis, a complex pathway in which CO_2 and water (H_2O) are fixed, split and made into sugar. Just remember the intricate graphics your biology teacher would attempt to depict on the blackboard, and then recall your attention invariably shifting from the classroom to the view outside. The sugars that are synthesized are the plant's energy source, and are either stored or metabolized. Recently, they have also been shown to stimulate the expression of certain proteins. So, in a nutshell, thanks to sunlight, plants can grow.

Hundreds of enzymes are thrust into action when light hits a budding flower. Among these enzymes are those involved in synthesizing, transporting, storing and breaking down energy sources, i.e. sugars. The specific role of rose vacuolar invertase acid beta-fructofuranosidase 1, or RhVI1, is to break down sugars, namely sucrose, to produce monosaccharides – such as glucose – which are then broken down to assist the rose bud in blooming and developing into a flower. There are reasons to believe that the release of monosaccharides may also have an effect on the osmotic pressure of different cell compartments – such as the vacuole – causing the plant cell to expand, which is also a prerequisite for bud bursting. So the breakdown of sucrose by RhVI1 could have a dual action.

RhVI1 is located in parts of the rose where it is required most, and where there is a singular need for sugars, that is to say in the plant's buds, its stems, its roots and its shoots. RhVI1 belongs to a large family of enzymes known as invertases, which are usually membrane-free. RhVI1, however, is anchored in the cell's vacuole membrane – a compartment that takes up a great portion of a plant cell and which is full of water and inorganic and organic molecules, as well as soluble enzymes. RhVI1 from *Rosa hybrida* has been closely studied: although built like all its invertase isoforms, it has the peculiarity of being anchored – as a monomer – to the cytosolic side of the vacuole's membrane. Consequently, besides breaking down sucrose as an energy source, RhVI1 may well be involved – as mentioned – in the regulation of monosaccharide concentration inside the vacuole, and hence in its osmotic pressure.

RhVI1 breaks down sucrose. Recently, sucrose was also found to act as a signal to promote both the expression of proteins and their activity. This is precisely what happens with RhVI1. When sucrose levels become high, scientists discovered that sucrose itself can act as a signal by promoting the expression of RhVI1 and ultimately its activity during bud burst. So not only is sucrose an energy source for the plant but it can also regulate energy uptake – an ideal way of preserving a certain kind of balance. What is more, plant hormones known as gibberellins also seem to act as signals for RhVI1 expression and activity, thus creating an equation where light, sucrose and gibberellins are three parameters involved in the regulation of bud burst.

Though far from understood in its entirety, this molecular unfolding of how roses bud and grow is naturally of great interest to all types of industry – pharmaceutical, cosmetic and food – besides the commerce of roses themselves. After thousands of years of continuous crossbreeding to produce the roses we know today, studies such as these may enable scientists to recover long lost traits of roses – such as their fragrance – but also strengthen other traits, or indeed re-orient them. Far more intriguing, though, is how nature has always simply turned to what the environment has to offer to grow and proliferate. Plants may be condemned to remain in one place for instance, but a long, long time ago they worked out a form of mobility by harnessing light and using it as a source of energy so that they could develop and multiply, while their roots spread below.

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